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Identification Through the Computerization of Dental Records

The use of dental records in forensic sciences is one of the accepted and time-honored methods of identification. A trained forensic odontologist is consulted when identification cannot be determined through visualization, fingerprints, personal effects, or other methods. Traditionally, the forensic odontologist studies the dentition, using charts, X-rays, photographs, and sometimes study models. He then compares his findings with records believed to be those of the subject in question to confirm or rule out positive identification.

Problem

The above method is satisfactory as long as the records presented to the odontologist lead to a positive identification. If there is no positive identification, usually the investigation ceases and the subject remains unidentified. The circularization of dental records is almost always futile. Such circularized records will not trigger the recall of a specific dentition by a practicing dentist, unless the dental conditions are extraordinarily unusual.

As of this date, there are no central repositories for identification through dental information. The dental data of specific cases collected by forensic odontologists, therefore, cannot be compared with any stored dental data.

There are about 3500 independent medical examiner's and coroner's offices in the United States, and with the present difficulty of communication through dental records, a possible 5000 to 7000 identifications per year are not made.[3]

Proposed Solution and Discussion

The most practical method by which masses of data can be compared is through the use of computers. As mentioned above, there are no systems that use this method of dental identification. A new dental charting system that provides the capability of processing dental data in a computer system has been developed and demonstrated by the authors. This system is logical, repeatable, and easy for the average dentist, with relatively complete dental records, to use. Because dental information is subject to change, the programming allows for sequential possibilities and recognizes impossibilities.

The dental profile chart, as developed by the authors, is described as follows (Fig. 1

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OFFICE OF THE CORONER
COUNTY OF SAN DIEGO, CALIFORNIA
FORM FOR THE COMPUTERIZATION OF DENTAL RECORDS

Nome or Coroner Case # 96 (M) F
Age of record ____ estimoted 45
Antemortem ✓
Postmortem ____
Date of X-rays 1974
Date of visuol exam ____
Today's date 2-29-76

Inquiring Office ____
Chorting Office ____
Charting Dentist S.S.

TOOTH NUMBER BY THE UNIVERSAL CODE: #1 is U R 3rd molar #32 is LR 3rd molar

	A	RESTORATIONS *1 M	O	D	B	L	DECAY BY SURFACE *2 M	O	D	B	L	B	C	D	E	F
1	/															
2			/													
3		/	/	/					✓							
A 4		/	/	/												
B 5		/	/	/												
C 6				4												
D 7				4												
E 8																
F 9																
G 10																
H 11				/		/										
I 12		2	2	2												
J 13		/	/	/												
14		/	/	/												
15		/	/													
16	/															
17	/															
18		2	2	2												
19	/	2	2	2	/	2										
K 20		2	2	2									9	10		
L 21			/	/												
M 22																
N 23																
O 24																
P 25																
Q 26																
R 27																
S 28			/	/												
T 29		/	/	/												
30		/	/	/												
31		/	/	/												
32	/															

A. STATUS IN SITU
1. missing
2. missing but open socket postmortem
3. deciduous
4. fractured ot gingiva
5. impocted
6. information not ovoilable
7. none of above

NOTE 1. Enter restoration moterial number for each surface restored (Table 1).
NOTE 2. Check each surfoce decoyed.

FIG. 1—*Previous generation of chart.*

TABLE 1—*Current generation of chart (see Fig. 1).*

Restoration Material

1. Amalgam
2. Gold, or gold substitute
3. Amalgam and gold
4. Acrylic or other anterior esthetic filling
5. Porcelain fused
6. Stainless steel crown
7. Swaged crown
8. Information not available
9. None of above

Columns B and C—Removable Appliances

1. All-acrylic partial denture
2. Cast frame partial denture
3. Natural tooth replaced by partial denture tooth, acrylic
4. Natural tooth replaced by partial denture tooth, porcelain
5. Natural tooth replaced by partial denture tooth, metal
6. Tooth clasped by partial denture, simple clasps
7. Tooth clasped by partial denture, precision or semiprecision
8. Full dentures, upper or lower, acrylic teeth
9. Full dentures, upper or lower, porcelain teeth
10. Information not available
11. None of above

Columns D, E, and F—Other Characteristics

1. Malocclusion Class I
2. Malocclusion Class II
3. Malocclusion Class III
4. Tilted mesially
5. Tilted distally
6. Tilted buccally
7. Tilted lingually or palatally
8. Mottling
9. Root canal therapy
10. Metal post in canal
11. Receded gingiva
12. Excessive wear
13. Abscessed or loose
14. Cusp of Carabelli
15. Shovel-shaped incisors
16. Negroid upper arch
17. Torus mandibularis or palatinus
18. Orthodontic band
19. Orthodontic arch wire
20. Rotated
21. Overhang of restoration
22. Root tip
23. Chipped
24. Study models available
25. Unique characteristics described below

Recording Dentist _____
Address _____
_____

Rules

1. Characteristics which refer to a non-tooth condition shall be noted once only under Tooth 1 (top line) or Tooth 17, under Column D; for example, torus mandibularis shall be noted as #17 in Space 17 D.

2. In reading X-rays, where the nature of metallic materials is unknown, it shall be considered as amalgam.

3. In reading X-rays, when a restoration can be determined to be either buccal or lingual, it shall be considered buccal.

4. In reading X-rays, when the buccal surface material of a crown or pontic is indeterminable, the buccal surface shall be charted as "Information not available" (#8).

5. If there are fewer pontics than the number of teeth missing, the pontics shall be charted on the lowest number(s) of the teeth missing.

and Table 1). The chart forms a grid. The teeth are numbered vertically by the Universal System, from 1 to 32. Column A describes the "Status in Situ." The next five columns describe existing restorations by surface. A code for the restoring material is employed. The next five columns note the decay, if present by surface. Columns B and C describe

the type of removable appliances, if any. Columns D, E, and F describe other possible characteristics.

This charting procedure produces a dental profile which is almost as descriptive as fingerprints. An actual case transposed onto a chart is shown in Fig. 1. Its computer readout is shown in Fig. 2.

History

In its original concept, the authors expected to use this new method to compare unknown deceased, comatose, or amnesic victims with known missing persons. For example, if a family or individual reported a person missing to the local authorities, the usual vital statistics would be taken. In addition, a copy of the dental profile chart (Fig. 1 and Table 1) would be issued to be completed by the individual's dentist. This dental profile chart would then be sent by teletype, telephone, or by mail to a central facility for entry into the computer. The forensic odontologist would do the same with the found individual and these data would be compared by the computer with the stored data. Those records given the greatest point correlations by the computer could then be retrieved and compared by the forensic odontologist. The computer method and point system developed and used by the authors will be discussed later in this report.

Meetings with computer experts in the identification section of the F.B.I. (October, 1975) confirmed that the chart was applicable to computer procedures but could not be put into effect for the following reasons:

1. There are over 150 000 *reported* missing persons per year, resulting in an expanded workload at a central repository.
2. It is not against federal law to disappear, and to place the dental profiles of these missing persons into a federal computer would violate their civil rights.

However, it was suggested that the data of found "unknowns" could be encoded and placed into computer storage. The family of the missing person possessing the dental profile form, and later a tape of this information, could request occasional computer comparisons. This information would not be stored.

Method

The procedure of comparing voluntarily offered dental information of missing persons with stored data of unknown individuals was implemented by the authors. This was accomplished by charting 100 dental records of actual patients selected at random.

Two data files were established from the selected charts. The first file contained the latest dental information compiled from charts and X-rays, thereby documenting all dental treatment completed. These data represented the postmortem records of unknown individuals charted by the forensic odontologist. This file is as complete as possible and up to date and contains relatively few errors. These data were entered in a Varian 620-L computer for storage.

The second file contained the earliest records of the selected 100 charts. This data file represented the earliest dental records of typical reports that might be filed by families of missing persons. Further, the data was characterized by dating back 20 years in some cases, being incomplete, and by containing some charting errors.

Using these two disparate files, correlation algorithms were developed and tested. A computerized correlation technique was designed and demonstrated based on the following ground rules.

1. The computer selects the best possible candidates from File 1, to an accuracy of 90%.

CASE NUMBER= 96 SEX= MALE EXAM AGE= 45 CURRENT AGE= 47
EXAM DATE= 1974 RECORD DATE= 1976 DENTIST= 595

TOOTH NR.	STATUS	A	RESTORATIONS BY SURFACE M	O	D	B	L	DECAY BY SURFACE M	O	D	B	L	REMOVABLE APPL. B	OTHER CHARACTERISTICS C	D	E	F
1	MISSING	1															
2	RESTORED	0	0	1	0	0	0	0	0	0	0	0	0	0	0		
3	NEW DECAY	0	1	1	1	0	0	0	0	1	0	0	0	0	0		
4	RESTORED	0	1	1	1	0	0	0	0	0	0	0	0	0	0		
5	RESTORED	0	1	1	1	0	0	0	0	0	0	0	0	0	0		
6	RESTORED	0	0	0	4	0	0	0	0	0	0	0	0	0	0		
7	RESTORED	0	0	0	4	0	0	0	0	0	0	0	0	0	0		
8	NORMAL	0															
9	NORMAL	0															
10	NORMAL	0															
11	RESTORED	0	0	0	1	0	1	0	0	0	0	0	0	0	0		
12	RESTORED	0	2	2	2	0	0	0	0	0	0	0	0	0	0		
13	RESTORED	0	1	1	1	0	0	0	0	0	0	0	0	0	0		
14	RESTORED	0	1	1	1	0	0	0	0	0	0	0	0	0	0		
15	RESTORED	0	1	1	0	0	0	0	0	0	0	0	0	0	0		
16	MISSING	1															
17	MISSING	1															
18	RESTORED	0	2	2	2	0	0	0	0	0	0	0	0	0	0		
19	ARTIFICAL	1	2	2	2	7	2	0	0	0	0	0	0	0	0		
20	RESTORED	0	2	2	2	0	0	0	0	0	0	0	0	9	10		
21	RESTORED	0	0	1	1	0	0	0	0	0	0	0	0	0	0		
22	NORMAL	0															
23	NORMAL	0															
24	NORMAL	0															
25	NORMAL	0															
26	NORMAL	0															
27	NORMAL	0															
28	RESTORED	0	0	1	1	0	0	0	0	0	0	0	0	0	0		
29	RESTORED	0	1	1	1	0	0	0	0	0	0	0	0	0	0		
30	RESTORED	0	1	1	1	0	0	0	0	0	0	0	0	0	0		
31	RESTORED	0	1	1	1	0	0	0	0	0	0	0	0	0	0		
32	MISSING	1															

FIG. 2—*Computer readout of Fig. 1.*

2. Postmortem estimate of unknown's age is assumed to be accurate to ±20% of actual age.
3. Sex or age, or both, may be unknown.
4. Any number of tooth characteristics may be unknown or omitted.
5. All age groups are to be included.
5. The transition from deciduous to permanent dentition must be allowed.
7. Sequential dental treatment must be allowed.
8. The processing time must be held to a reasonable minimum. (Processing time is defined as the time from the start of a test entry to the printout of possible candidates.)
9. Charting errors must be allowed.

Based on the above requirements, a computer program was developed to select the best possible candidates from postmortem or unknown individual records with respect to a known antemortem dental profile. The logic of this software program was basically the same as if the selection of possible candidates were done by manually comparing each dental record on file with the test case, tooth by tooth, sex by sex, age by age, and so on. The selection and elimination processes were essentially the same. For example, if the sex of the test case were male, then all female postmortem cases could most likely be eliminated. There always remained, of course, the possibility that a mistake was made in charting or in the entering of computer data. It was also possible that the sex of the unknown victim was indeterminate.

Computer Application

The computerization method used must allow the following processes:

(1) the easy input of data,
(2) the easy correction and updating of stored data,
(3) rapid comparison with stored data, as mentioned above,
(4) the inclusion of a point scoring system that rewards correlative data and subtracts points where data do not match sequential possibilities, and
(5) the display or printout of the candidates and their scores in descending order of probability.

For situations ranging from several hundred victims of a commercial jet disaster to thousands of entries, a general purpose, inexpensive, digital minicomputer can be used. A Varian 620-L computer was used in testing the hundred cases reported in this article. Attached was a keyboard input, a disk storage system, magnetic tape storage, and a cathode-ray tube display.

A program was designed that guided the precise entry of data and minimized operator error. Questions were displayed to the operator and answers typed in reply:

1. What is the case number? _____
2. What is the sex and age? _____ _____
3. What is the examination date? _____ _____ _____
4. Enter tooth #1 Status. _____
5. Enter tooth #1 Restorations. _____ _____ _____ _____ _____
6. Enter tooth #1 Decay. _____ _____ _____ _____ _____
7. Enter tooth #1 Removable Appliance. _____ _____
8. Enter tooth #1 Other Characteristics. _____ _____ _____
9. Enter tooth #2 Status. _____

The authors decided to store each tooth's characteristics as a separate and complete record, so that each tooth could be recalled by itself from storage at a later time for

either change or processing. This procedure also allows the testing of other correlation scoring methods that could be dependent on or independent of tooth positions.

The scoring weights developed and used for the Status position are displayed in Fig. 3. The antemortem status is along the vertical axis and the postmortem is horizontal. For example, if the antemortem status of a tooth is missing and the postmortem status of that tooth is missing, 100 points are added to the score. If, however, the postmortem status of the same tooth is "missing but open socket," then that meant the tooth was present at, or very close to, the time of death. Since this situation is an inconsistency, 100 points are deducted.

For the "Restorations" and "Decay" surfaces, where there are direct correlative matches, 5 points are added for each matching surface. Where sequential possibilities occurred, no points were added. Where there were inconsistencies, varying points were subtracted for each.

The above method allowed scoring and the display of the candidates and their scores within 2 min in the testing and demonstrations. This time can be significantly reduced by eliminating cases with major discrepancies. Of the 100 test antemortem cases entered, the computer selected the correct candidate in 85 cases. In the remaining 15 cases the computer displayed the correct candidate in the top 5% of the scores. These latter cases typically represented great changes in the mouth, such as change from deciduous to permanent dentition, or adults having extensive dental treatment between the initial antemortem and postmortem entries. Submitting partial records (as little as six teeth) or deliberate errors did not prevent correct chart selection.

The scoring system can be adjusted to the requirements. With systems involving thousands of stored cases, special differentiation weighing systems can be developed. For example, the greatly divergent nature of the first molar can be given greater weight than that of the lower central incisor.

Recommendations

1. Practical use of this method should be tested on a regional or national basis, incorporating all coroner's and medical examiner's offices, hospitals, correctional institutions, and so on.

2. Existing computerized dental records involving insurance should be expanded through the use of standardized computer charts. This procedure would provide a large source of information for the identification of unknown individuals.

3. The armed forces can readily find this method useful for identification, since complete dental X-rays and records are maintained. Dental data can be entered into the computer bank for each serviceman. Subsequent changes can be added as dental procedures are completed. In the identification of wartime casualties, often dog tags, fingerprints, and other identifying marks may be obliterated or missing. If dental structures remain, the dental profile can be entered into the computer for a rapid comparison. It is obvious that this method could save countless man-hours by retrieving, sorting, and evaluating comparisons in minutes. Thus, possibly, future "Tombs of Unknown Soldiers" may be avoided.

4. In the event of mass disasters, such as aircraft crashes or the 1976 Colorado floods, the application of this system is obvious. In Colorado, although many missing persons reports were filed, many individuals remained unidentified weeks after the disaster. It is therefore recommended that the concepts of this paper be implemented in future planning for emergency disaster procedures.

Conclusions

The rapid screening and comparing of dental information for identification purposes

POSTMORTEM (PM)

ANTEMORTEM (AM) STATUS IN SITU	0 Present	1 Missing	2 Missing open socket	3 Deciduous	4 Fractured	5 Impacted	6 No info
0 Present	note 1	0	25 note 2	−100 note 3	0	−100	25 note 2
1 Missing	−100	100	−100	−100	−100	0	25 note 2
2 Missing open socket	25	−100	25	25	−100	25	25 note 2
3 Deciduous	25	0	25	note 1	0	25	25 note 2
4 Fractured	−100	0	0	−100	100	−100	25 note 2
5 Impacted	−100 note 4	0	−100	−100	−100	100	25 note 2
6 No info	25	25	25	25	25	25	25 note 2

Notes:
1. 5 points per matching restored surface
   5 points per matching restoration material
   0 points for PM restoration, AM nondecayed per surface
   −100 points for AM restored, PM nondecayed per surface
   0 points for AM no decay, PM decay per surface
   − 25 points for AM decayed, PM nondecayed per surface
2. Default score
3. Score per note 1 if AM age <14
   −100 points in AM age >14
4. −100 points in AM age >13
   25 points in AM age <13

FIG. 3—*Scoring weights per tooth status, antemortem to postmortem.*

has been described. Through the use of a dental profile form and computer, the authors have tested and demonstrated the practicability and accuracy of this method.

A simple, inexpensive, portable computer system can be used. This method can be of help in the identification of those now remaining unidentified and can also help reduce the time required for identification in mass disasters.

The described computer system is flexible because it allows comparison of missing persons' dental data against unknown individuals' dental data, as well as comparison of the unknown individuals' dental data against missing persons' dental data. It also provides for any unique requirement.

It is essential to note that the use of a computer system does not relieve the forensic odontologist from the responsibility of making the final positive identification. The system is merely a tool for providing the best candidates for comparisons of records by the forensic specialist.

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